GLOBAL EXPERT WORKSHOP ON HARMONIZATION OF METHODOLOGIES FOR TEST FACILITIES OF BALLAST WATER MANAGEMENT SYSTEMS

24-25 January 2010

World Maritime University, Malmö, Sweden

Workshop Report
compiled by Dr. Stephan Gollasch, consultant

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1. Introduction

The GloBallast PCU implemented an activity under Global Industry Alliance (GIA) Fund, endorsed by the GIA Task Force and approved by IMO, to coordinate a global Forum for Test Facilities for Ballast Water Management Systems (BWMS).

There is an urgent need within the shipping industry for the development of cost-effective and environmentally friendly BWMSs. Driven by this need, the technology community has been actively developing various BWMSs to cater to the emerging ballast water technology market. Such systems are required to undergo various testing and approval processes, as per the *International Convention on the Management of Ships' Ballast Water and Sediments* (IMO Convention, 2004) and its Guidelines, including land-based testing under challenging conditions.

While several BWMSs are currently being developed or approved, testing among ballast water management system test facilities (TFs) around the world is inconsistent and significant methodological gaps remain. This incongruity has contributed to confusion and lack of confidence among the technology developers as well as ship owners. It is imperative that end users of such systems have confidence reliable and consistent test methodologies are used, as the shipping community expects that a BWMS receiving Type Approval from one Administration will be accepted by all other Administrations at their respective ports irrespective of which facility was used to test the system.

Currently, there are more than 10 established TFs in different stages of development or operation and thus, their researchers have varied levels of experience in the testing process. Although Guidelines under the Convention indicate the criteria BWMSs must meet and do provide general guidance on testing methodologies, there is still no agreed-upon and harmonized view of how certain items required by the G8 Guidelines should be measured. During the 58th session of the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO), an informal meeting was held with representatives of several TFs, who confirmed the need for improved dialogue on technical issues. Indeed, this point was also noted by MEPC itself. Furthermore, during the recent 5th Annual Ballast Water Management Conference, held in London in December 2009, this topic was discussed in detail, and GloBallast was asked to facilitate a dialogue among operators of TFs by organizing the first Global Expert Workshop on the harmonization of methodologies (Workshop) among the existing TFs.

To facilitate the development of the Workshop, a Correspondence Group including all test facility operators was established by the GloBallast PCU, and participants worked together to identify possible outcomes. On 24-25 January 2010, the Workshop was held at the World Maritime University in Malmö, Sweden; it was sponsored by the Global Industry Alliance (GIA) Fund, endorsed by the GIA Task Force, and approved by IMO. The activity provided a neutral platform for discussions, while at the same time, it encouraged an active and results-oriented dialogue. This approach benefited the community of TF operators as well as the users of TFs as participants discussed how to guarantee results among TFs are—to the extent possible—comparable. For the end users of the treatment technologies, the initiative will ensure reliable testing of treatment systems and information about the systems on the market will be comparable, i.e., a greater level of transparency relative to the present level will be achieved. Ultimately, these measures will contribute to the efficient and timely implementation and ratification of the Convention.

Notably, this Workshop was the first of its kind and never before were so many of the existing test facilities brought together to discuss their approaches and methods. In advance, it was agreed that this event could not solve all harmonization needs during the G8 tests, but instead, its objective was to address the most important harmonization items.

It was recommended that future workshops of a similar nature be held to address outstanding harmonization items. One option would be to arrange the 2nd Test Site Harmonisation Workshop in the fall, possibly in close linkage with the 5th International Conference & Exhibition on Ballast Water Management (ICBWM) 2010, to be held in Singapore from November 1 to 4 2010.

2. Purpose of this Document

This document summarizes the findings of the Workshop, held in Malmö, Sweden on January 24 and 25 2010.

3. Structure of the Workshop

The workshop was held at World Maritime University (WMU), Malmö, Sweden hosted by WMU and facilitated by Dr. Stephan Gollasch, GoConsult, Hamburg, Germany. The workshop was initiated by GloBallast Partnerships with the Global Industry Alliance as funding source for the event. In total 29 participants from 9 countries attended the meeting (see Appendix 1 List of Participants). Apologies were received from Richard Everett, USA; the National Institute for Oceanography, India; Resource Ballast Technologies Ltd, South Africa; and the TF operators in China. Due to overlapping commitments, they were unable to attend.

The meeting was opened at 09.00 on Sunday, 24 January 2010 with welcoming remarks from Professor Olof Linden, WMU and with Mr. Dandu Pughiuc, IMO addressing the Workshop.

The meeting took the form of a series of plenary sessions with presentations given by representatives from the TFs. Further, the chairman of the GESAMP Ballast Water Working Group and one participant of this GESAMP group were invited to give presentations addressing the Whole Effluent Tests (WET), required by IMO Guideline G9 (IMO, 2008) and implications such a land-based WET test may have during tests of BWMSs according to Guideline G8 (IMO, 2008).

Lively discussions developed following each of the presentations. In the afternoon of Day One and on Day Two breakout groups were formed (Appendix 3) to discuss urgent harmonization items and how to address them. Results of the discussion were later presented in a final plenary session. Finally, the participants considered the outcomes of all discussions at a concluding session of the workshop (Monday, 25 January 2010 at 18.00).

4. The test facilities

Developing test facilities in Denmark (DHI), India, Japan, Singapore (DHI) and South Africa as well as the facilities with experience in land-based tests of BWMSs, i.e., Korea (KORDI and KOMERI), Norway (NIVA), The Netherlands (NIOZ), and the USA (MERC, GSI, NRL) gave presentations at the workshop addressing the following topics:

- facility organization and funding,
- facility location and physical/biological conditions,
- facility infrastructure and testing team,
- overview of basic testing approaches and methods,
- testing completed to date, and
- key challenges to testing and priority areas for harmonization.

It became clear that the various test facilities considered during the workshop are in different stages of development. In addition to facilities with more experience running tests, other facilities are planning to start their services very soon, i.e., later in 2010.

Further, as the description below illustrates, the test facilities operate in very different ways and with very different structures in terms of funding, etc.

There are also differences in terms of the administrative process of certification tests and for overseeing of the test facilities, e.g. NIOZ is a centralized facility run by an independent scientific institution. In Japan and Korea, the facilities are also overseen by the administration, but the test platform itself is provided by and the tests are run by the BWMS manufacturers.

Annex 5 gives an overview of the TFs introduced at the workshop also including data provided by correspondence of the TFs unable to attend, India and South Africa.

5. Summary of water parameters at each test facility

The natural water quality parameters (Table 1) at selected facilities clearly show that ambient water conditions do not always meet the standards required by IMO Guideline G8 for the land-based tests. To meet the G8 challenge water requirements, substances and organisms may have to be added to the water. Please note that some facilities have more than one test location (see above) and in these cases the parameter range over all test locations of one facility was included in this table.

Table 1. Summary of ambient water parameters in at different test sites.

Parameter	**NIOZ Netherlands**	**MERC USA**	**GSI USA**	**NRL USA**	**DHI Denmark**	**DHI Singapore**	**KOMERI Korea**	**KORDI Korea**	**SWBWTCS China**	**NIVA Norway**	**MRDTC Japan**
Temp (°C)	variable	4 – 30	9 – 22	20 – 32	variable	28 – 31	4.7 – 22.9	3.1 – 29.0	16 – 22	2 – 15	8 – 25
Salinity (PSU)	20 - 34	5 – 25	0 – 1	35 – 41	0 – 33	<0.3 – 32.2	30.3 – 34.3	21.1 – 33.8	32 – 33	0 – 34	31 – 34
TSS (mg l^{-1})	5 – 400	1 – 60	2 – 21	1 - 5 [1]	variable	1.6 – 54	variable	20 – 90	1 – 5	variable	5 – 11
POC (mg l^{-1})	5 – 20	0.5 – 8	< 1	2 – 4	> 5	variable	1.1 – 28.8	0.4 – 5.9	ca. 5	variable	<0.1 – 1.7
DOC (mg l^{-1})	1 – 5	2 - 10	6 – 22	2 – 4	> 10	variable	5.7 – 12.0	0.3 – 32.8	ca. 2	variable	1.0 – 1.5
Organisms ≥ 50 µm m^{-3}	10,000 – 1,000,000	10,000 - 300,000	100,000 - 3,000,000	50,000 – 180,000	variable	$10^5 – 10^6$	3,220 – 78,720	1 – 100 x 10^5	standard met	variable	5.8 x 10^3 – 5.3 x 10^5
Organisms < 50 µm and ≥ 10 µm ml^{-1}	100 – 100,000	500 - 15,000	25 - 1,200	ca. 10 – 200	variable	$10^2 – 10^4$	1 - > 800	120 - > 209,100	50 % of standard	variable	variable
Heterotrophic bacteria ml^{-1}	10,000 – 10,000,000	10,000 - 10,000,000	> 1,000	10^5 - 10^7	variable	10^4 - 10^6	variable	0.2 – 12.7 x 10^6	standard met	variable	variable

[1] As Mineral Matter (MM).

6. Possible Harmonization Items

The facility representatives were asked to present a list of potential discussion items with the aim of stimulating a discussion of parameters requiring harmonization. After all presentations were given, the suggested harmonization items were quickly summarized and handed over to the breakout groups as starting point for their discussions.

7. Minutes of discussions

During the first session of the breakout discussion groups and subsequently of the plenary discussions, the following items where agreed as of high priority for harmonization:

- **QA \ QC \ GLP**
- **Documentation**
- **Manipulation of test water**
- **Standardization of the sampling approach**

All harmonization items identified by the test facility representatives are attached as Appendix 4. Due to time constraints, not all high-priority items could be addressed in the same level of detail, and the following section summarizes the workshop findings based upon further breakout group and plenary discussions.

8. Results of discussions on TOP priority harmonization items

8.1 QA \ QC \ GLP

The facilities agreed to make all Quality Assurance and Quality Control (QA \ QC) as well Good Laboratory Practice (GLP) plans publicly available with the aim to evaluate practices and compare them among TFs. The QA \ QC protocols should address all factors, i.e., water parameters, chemical, physical, biological and toxicological aspects, etc.

The most critical part to harmonize among test facilities is the biology. At present, using one approach to determine viability is difficult because

- The organisms at TFs are intrinsically different;
- The biological methodologies are constantly being further developed and improved;
- Methods can be evaluated only if full disclosure of the methods and results is made; however, in some cases, TFs have said this is not possible, due to conflicts of intellectual property rights, etc.
- Standarizations can only be made on the basis of what methods are currently in use and have been reasonably established. In this environment developments may not sprout easily, in fact it is rather the opposite from the innovative interface.
- Organisms behave less predictably compared to chemicals which may make an intercalibration more difficult. Consequently the QA \ OC for biological aspects may have to be approached different compared to other subjects.

- It was pointed out, however, that full disclosure and complete transparency is highly encouraged to allow Administrations the ability to accurately assess any TF's results. Also, any method used should be validated to demonstrate to the scientific community and Administrations that it is appropriate and acceptable to use.

Workshop participants agreed to achieve transparency among TFs by disclosing how each TF conducts a test, which would help to assure quality so administrations can make an informed judgement upon:

- Documentation of test results, including:
    - Mistakes;
    - Unexpected results; and
    - Deviations from originally agreed work plans and approaches.
- Procedures for auditing
- Exchange of scientists between laboratories
- Procedures for independent testings by the treatment system manufacturer itself to prevent conflicts of interest.

It was also suggested that to protect integrity of test reporting a clause in the test agreement between test facility and the manufacturer should be added to agree on the possible dissemination and use of the test data for e.g. publications in scientific journals.

Some test data may supersede the G8, e.g. treatment efficacy of organisms below 10 µm in minimum dimension. These data are not usually forwarded to the administration as they lie outside the scope of the test report, but they are suitable for publication, in particular when issues of common interest exist, such as processes that result in affecting certain measurements and the efficacy of BWMSs may curb the whole spectrum of non-indigenous species and harmful algae as many of such species are below the 10 µm threshold.

Furthermore, it was pointed out that the limitations of a BWMS need to be provided by the manufacturer, as required by the certificate.

Finally, it was agreed that initially the interpretation of G8 in the beginning was substantially different among TFs, but has since been converging over time.

8.2 Documentation

The reporting format of G8 test results reports, which are written by test facilities for manufacturers to submit to Administrations, should be standardized. This standardization refers in particular to the parameters deemed necessary for inclusion for the non-confidential part of the reports (manufacturer's specifications, etc.). This outline would provide the basis of the report to be written to the Administration for wider circulation, the confidential parts would simply be removed.

The documentation format may also be used for the submission to the IMO GISIS database, which is required by resolution MEPC.175(58), Information Reporting on Type Approved Ballast Water Management Systems, and the submission may include data regarding the facility, QA \ QC documentation, biology, physical and chemical parameters, sampling, validation criteria, the methods used and the test results.

The following details are considered minimum requirements regarding the documentation for test reports.

Facility

Include a narrative description of the facility: location, size of tanks, whether tanks are filled simultaneously or sequentially, how water flow and pressure are controlled, average ambient organism concentration and diversity, range in physical water parameters (e.g. temperature, salinity, DOC, POC, and TSS). List the parties involved in the test (i.e., manufacturer, test facility, subcontractors for analysis).

QA \ QC Documentation

If the test facility did not previously submit the QA \ QC documentation to the Administration prior to the test, it should be submitted with the test report.

Biology

If surrogates are being used, describe the species and provide a justification for use of the surrogates, e.g., temperature and salinity tolerance of the organisms compared to ambient conditions, consider the behaviour and potential interaction of natural species vs. surrogates. Also include the percentage ratio of challenge organisms that are surrogates vs. naturally occurring species in the challenge water.

Describe the dominant species composition of ambient organisms considering seasonal aspects.

The method by which organisms minimum dimensions are measured (e.g., if an organism is retained on a 50 µm mesh it is considered as ≥ 50 µm in minimum dimension or other methods and whether or not the organism counts are undertaken with automated systems).

Physical and chemical parameters

List any amendments to ambient water and provide a justification for the use of the amendments. Provide details on when in the test cycles the parameters (e.g. TSS, DOC, and POC) were measured.

Sampling

Provide details on

- Method and frequency of measuring water flow and pressure (e.g., automated measurements at five-minute intervals),
- Mortality of all organisms present after challenge organisms were added (requires collecting and enumerating organisms before and after their addition to the system),
- Type of pumps and valves used to sample organisms,
- Sample volumes for all size classes,

- Justification that representative samples are collected (e.g., a time-averaged sample collected over the entire filling or draining of a test tank vs. samples collected at the beginning/middle/end, isokinetic sampling, re-suspension of sediment at the bottom of the tank)

Additional validation criteria (if any, e.g., mortality rate of pumps on large organisms, impact of pressure and larger flow rates on organisms)

Enrichment of native organisms
- Were ambient organisms concentrated to meet challenge water conditions?
    - If so, describe the process for harvesting organisms, including the length of the harvesting process and how organisms were held prior to the test.
- Protocols for determining viability of all organisms groups.

Results
Provide comprehensive results from testing. In addition, provide the percent survival of large and small organisms that are ambient organisms and surrogates in both control and treatment tanks.

All test results, including ones in which the BWTS failed, should have to be reported to the administration involved in the certification process for e.g., the identification of appropriate (valid) test runs. This decision should not be the responsibility of the facility operator.

8.3 Manipulation of test water

The views on manipulation of test water diverge. Facilities add abiotic material or organisms or both to the ambient water at least during some time of the year to meet the requirements set forth in G8, and the manner in which TFs do so differs (e.g., adding naturally occurring sediment vs. commercially purchased sediment). However, at least one TF has unpublished data showing this manipulation has a negative impact on organism survival, which is especially of importance during the required 5-day holding time.

Subject to a manipulation, if necessary, may be
- Physical factors, e.g., salinity, temperature, TSS;
- Chemical factors, e.g., POC, DOC; and
- Biological factors, e.g., organisms.

The group agreed that no manipulation of challenge water would be preferred, but it would be difficult to meet all G8 requirements at all times. A discussion about eliminating challenge conditions ensued, but given the scarcity of data to support that drastic change, it was concluded that challenge conditions should remain as defined in G8. However, it was strongly recommended that the manipulation must be kept to the minimum level possible, e.g., only adding physical, chemical, or biological constituents when the ambient water does not meet the challenge conditions for that parameter. In cases where organisms need to be added, the use of native species is preferable. In cases where this cannot be done, it should by all means be ensured that the non-native species in use cannot enter the environment to eliminate the risk of accidentally introducing the species in open water near the test site. This task may be done by a quarantine measure implemented to ensure that the waters surrounding the test facility are not negatively impacted. In some countries the use of non-indigenous surrogate organisms would be subject to permission and to acquire such a permit may be a process of years.

In cases where a manipulation of the test water is essential, this should be done in the same fashion (methods, parameters, etc) during all tests of the treatment system under consideration at this site, i.e., throughout all tests. There was no discussion in the plenary session about how to compare methods of manipulating challenge water.

Should such a manipulation be undertaken the following information should be provided:

- Substantiating the need to manipulate the challenge water; and
- Evaluation of the advantages and possible disadvantage of such a manipulation.

Such data may be provided by a compilation of protocols from test facility or a questionnaire to address

- Ambient factors: temperature range, salinity range, TSS, etc;
- Dominant organisms in ambient water (size, number, method of collection, method of concentration, etc);
- Manipulation materials to increase TSS, POC, organisms, etc;
- Infrastructure of the test facility (piping, flow rate, etc);
- Methods of result verification (confirmation of no artifacts);
- Necessity of action to collect/distribute information (who? when?);
- Maintenance of the validation protocol, training of personnel;
- Relevant standards, e.g., ISO7025; and
- Intercalibration of methods to be used.

It was also suggested to run test trials with natural challenge water vs. manipulated challenge water to assess what impact such manipulation on the system performance and organism survival (of the control water) may have. The risk to generate an artefact should be kept as low as possible.

8.4 Standardization of the sampling approach

Due to time constraints, sampling approach standardization aspects were only briefly discussed and it is hoped that this important harmonization item may be discussed at a future meeting. However, the reporting on sampling procedures was discussed and is captured in the previous section 9.2 of this report.

9. Recommendations

During the concluding discussions the following recommendations regarding priority harmonization items were made:

- Compile and share QA \ QC protocols of all facilities, in particular for biological aspects.

- Insure the integrity of datasets: TFs should send all test results (including unsuccessful or uncompleted tests) to the relevant Administration, and it will be up to the Administration to decide upon test validity and failure.

- Develop guidance for the evaluation whether or not challenge water conditions need to be manipulated and, if so desired, develop a strategy and methods for such a manipulation of the challenge water conditions to meet all G8 requirements, e.g. the minimum intake organism concentration, TSS content etc.

- Devise standardized reporting of (a) methods used and (b) test results to the Administration. Note that the G8 WET tests have implications also for the required G9 tests.

- Ensure that such a harmonization effort be continued and inform IMO member countries of the harmonization efforts through the IMO / GloBallast Secretariat as appropriate.

To achieve the above, a correspondence group will be established and workshop participants have volunteered to facilitate the agreed-upon action points:

Action item	Tine frame	Facilitator
Setting up a website "International Consortium of land-based Ballast Water Treatment System Test Sites"	End of February 2010	MERC, USA
Compile and share QA \ QC protocols	Information request to be sent to all facilities soon, response requested by early March 2010	GSI, USA
Status report on challenge water manipulation	A questionnaire sent to all facilities by March 2010	NIVA, Norway
Model results and test run report for Administrations	< October 2010	NIOZ, the Netherlands
Organization of 2nd Test Facility Workshop	Short term	DHI, Singapore / GloBallast / GIA
Submission of a "Note from the Secretariat" to MEPC61 on the results of the test facility harmonization workshop.	Short term	GloBallast

10. Workshop Concluding Remarks

Fir the first time, this Workshop brought representatives from almost all TFs of BWMSs together to exchange their approaches and share experience gained during the planning, construction, and operation of the facilities which was already considered as a great success.

The need for test facility harmonization has also been expressed by the end-users of ballast water treatment technologies. Workshop participants agreed that such harmonization among TFs would send positive signals to the end-user community and would boost the confidence among this community as they prepare to install treatment technologies onboard ships.

Shortly after the discussions started, it became clear that a two-day workshop cannot result in a harmonized test procedure of all sites, as the work is very complex. It was concluded that the harmonization between TFs is essential and that future events are needed to agree on and address harmonization items. Consequently, an action plan was prepared (see above).

The participants felt that the experience gained during tests of BWMSs may lead to proposals to amend, as appropriate, items in Guideline G8. It was therefore suggested that such possible amendments may be considered in the future.

All participants expressed their grateful thanks to the Global Industry Alliance and the GloBallast Partnerships far having made this workshop possible.

GloBallast Partnerships will endeavour to support the further development of this harmonization initiative, and to keep the momentum, it will provide secretarial support as appropriate, e.g., continue to facilitate the correspondence group so an active exchange of views continues.

It was agreed by the workshop participants that a series of workshops will be needed to achieve the outstanding harmonization needs. A second ballast water treatment facility harmonization workshop (see action items) is planned to be held back-to-back with the 5th International Conference & Exhibition on Ballast Water Management (ICBWM) 2010 in November 2010 in Singapore.

11. References

International Maritime Organization (2004) Convention BWM/CONF/36 ‘International Convention for the Control and Management of Ships’ Ballast Water and Sediments, 2004

International Maritime Organization (2005) Resolution MEPC.125(53) ‘Guidelines for Approval of Ballast Water Management Systems (G8)

International Maritime Organization (2008) Resolution MEPC.169(57) ‘Procedure for Approval of Ballast Water Management Systems that make use of Active Substances (G9)

Appendices

1 List of Participants

2 Workshop Agenda

3 Breakout groups

4 Priority items for harmonization

5 Description of facilities

Appendix 1 List of Participants

Allegra Cangelosi
Great Ships Initiative/Northeast-Midwest Institute
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International Maritime Organization

Fredrik Haag
International Maritime Organization

Robert Macciochi
International Maritime Organization

Mia Hedin
World Maritime University

Appendix 2 Workshop Agenda

Sunday, 24 January 2010

9.00 am
Opening session

- Welcoming remarks (10 minutes), D. Pughiuc, IMO
- Introduction to the workshop (10 minutes), S. Gollasch, forum facilitator
- Objectives, structure, work plan (10 minutes), S. Gollasch, forum facilitator

9.30 pm
Introduction of test facilities

- Japan – presented by Yasunobu Araki
  The administrative framework to establish a test facility in Japan and its additional requirements for G8 test-bed tests
- India (presented by Jose Matheickal)
- Korea

10.30 am

Morning coffee break

11.00 am
Continue with test facility presentations

- The Netherlands
- Norway
- Denmark
- Singapore

12 noon

Lunch break

1.30 pm
Continue with test facility presentations

- USA (three facilities)

- Presentation by Jan Linders (GESAMP BWWG Chair)
- Presentation by Shinichi Hanayama (member of GESAMP BWWG)
  Methodology for the eco-toxicity testing for a Final Approval under G9, associated with G8 efficacy testing.

3.00 pm

Afternoon coffee break

3.30 pm

- Identification of discussion items, to be discussed in groups, i.e. those test facility attributes or processes which are critical for standardization, e.g. QA\QC, viability assessments, sampling frequency and number, sample treatment prior analysis

  Each group should discuss these items from the perspective of:

  - Comparability/variability issues
  - Suggestions for approaches to standardization
  - Appropriate methodology, criteria and process for test facility validation.
  - The Administrations view

- Forming of three break out groups to discuss harmonization items as identified in earlier session

4.30 pm

- Break out group discussions

6.00 pm end of Day 1

Monday, 25 January 2010

9.00 am

- Break out group discussions continue

10.30 am

Morning coffee break

11.00 am

- Presentations of break out group findings
  - Group 1
  - Group 2
  - Group 3

12.00 pm

Lunch break

1.30 pm

- Plenary discussion on break out group findings

3.00 pm

Afternoon coffee break

3.30 pm

- Findings and conclusions
    - Availability and status of worldwide test facilities
    - Differences between test facilities
    - Harmonization needs and possible approaches

- Possible outputs (e.g. submission to MEPC)

- Additional items for discussion – future scenarios
    - Discuss the Terms of Reference for future fora to achieve the desired product(s) in a timely fashion
    - Arrangement for sharing of information and discussion of issues
    - Cross calibration exercises to assess the variance
    - Predictiveness of IMO-consistent land-based tests relative to on-ship performance of ballast water treatment systems

5.45

Closing remarks, J. Matheickal, IMO-GloBallast

Appendix 3 Breakout groups

The rapporteurs (in bold below) and members of each of the three breakout groups:

GROUP 1	GROUP 2	GROUP 3
Cato Ten Hallers-Tjabbes	**Yasuwo Fukuyo**	**Lisa Drake**
Allegra Cangelosi	Kim Gustavson	Sjur Tveite
Tor Gunnar Jantsch	Claus Jorgensen	Frank Fuhr
Marcel Veldhuis	Yourysoo Kim	Yasunobu Araki
Kyongsoon Shin	Mia Steinberg	Martin Andersen
Gitte I. Petersen	Mario Tamburri	Etienne Brutel de la Riviere
Shinichi Maruta	Eun-Chan Kim	Sung-Jin Park
Jan Linders	Kitae Rhie	Shinichi Hanayama
Carolyn Juneman		

Appendix 4 Priority items for harmonization

Additional harmonization items have been agreed by the participants addressing the test facility, Whole Effluent Tests (G9), sample taking, use of test or ambient organisms, scaling, and the interpretation of Guidelines.

Test Facility

- How to mimic a ballast water tank (e.g., in-tank structures, coatings)
- For ballast water treatment systems that treat water (also) on discharge, how to treat the water on discharge after 5-day holding time
- If and how to re-suspend TSS from bottom
- Position and design sampling points, valves
- Define test failure criteria
- Facility validation
- Intercalibration between test facilities (possibly test one treatment system at different sites)

Whole Effluent Tests (G9)

- Timing of sample taking
- Holding times
- Can chronic tests be bypassed (Administration´s decision?)
- Sample storage before analysis if needed

Sample taking

- Minimum/maximum sample volume
- Sampling frequency
- Processing of sample between sample taking and start of sample processing
- Representative samplings

Organisms

- Viability assessment
- Assessment of minimum dimension
- Counting
- Ensuring accuracy
- Development of guidelines for the addition of organisms to the challenge water (if applicable)
- Development of strategies to prevent human error, artefacts

Scaling

Interpretation of Guidelines

Appendix 5 Brief description of the test facilities

The following section gives an overview of the TFs introduced at the workshop (in alphabetical order of the country where the facility is located) also including data provided by correspondence of the TFs unable to attend, India and South Africa.

China, SWBWTCS

Facility name: Shandong Weida Ballast Water Test & Certification System (SWBWTCS)

Author: Shandong Weida

Facility location: WEIHAI SHANDONG,CHINA

Ambient water parameters at site

- Temperature: 16-22°C from May to August
- Salinity: (32-33PSU),
- TSS 1-5mg/l,
- POC ≈5mg/l
- DOC ≈2mg/l
- Organism concentrations
  - >50 µm, meet the standard
  - <50 µm and > 10µm half of the standard
  - Heterotrophic bacteriae all to meet the standard

Site in operation since August 2008.

Overview of basic testing approaches and methods

Strictly according to IMO guideline (G2, G8, G9 etc).

Treatment system tests undertaken

Tests were undertaken for BOS BWMS of COSCO. The main components of BOS contained filter and UV.

List any unique features of the facility:

1. The testing base can accommodate 20 persons and it takes only 20 min drive to hotel in the downtown.
2. The testing base can provide some related services for the land-base testing.
3. The best price.
4. The surface of the ballast tanks and pipelines are all steel production.

Denmark, DHI
Singapore, DHI

Authors: Gitte I. Petersen (DHI, Denmark) and Martin Andersen (DHI, Singapore)

DHI Denmark Land Based Test Facility

Facility location

The DHI test facility including a mobile field laboratory will be placed at Hundested Harbour. The DHI head office and GLP laboratories is placed in Hoersholm. Personnel from the DHI head office can reach the test facility within 45 minutes and thus ensure that collected samples are analysed within the required time limit of 6 hours. Location of DHI head office and the DHI land based test facility is shown below (Fig. 1).

Fig. 1. Location of the DHI Denmark Land Based Test Facility.

Ambient water parameters at site

The Hundested Harbour area is an ideal location for full scale testing of BWMS as freshwater, brackish water and high saline seawater is in close proximity.

High saline water (>32 PSU) is available in the Kattegat where out flowing Baltic Sea water meets high salinity ocean water from the Skagerrak. The Kattegat surface water salinity varies from 12 to 30 PSU with a strong north-south gradient. The deep water below has a salinity ranging from 32 to 33 PSU. High biological production occurs in the halocline between surface water and high saline bottom water. With respect to the species diversity, the Kattegat is known for its natural richness and large diversity in organisms. Depending on weather conditions and time of the year, the water quality may fulfil the chemical criteria for dissolved organic carbon (DOC), particulate organic carbon (POC) and total suspended solids (TSS).

Brackish water (3-32 PSU) is available in the Roskildefjord/Isefjord, which is situated between the Arresø and the Kattegat. It is primarily surrounded by forest and farmland, and due to a variety of bays and inlets, the water exchange with the nearby Kattegat is low. The water in the area is brackish (salinity ~5-26 PSU). Depending on weather conditions and time of year, the water quality may fulfil the chemical criteria for DOC, POC and TSS. With respect to the species diversity, the Roskildefjord/Isefjord is, like the Kattegat, known for its natural richness and large diversity in organisms. Brackish water with salinity ranging between 14-26 PSU is found at the berth at Hundested Harbour.

Freshwater (<3 PSU) is available in the Arresø canal just before the freshwater enters the fjord/sea. The Arresø is the largest lake in Denmark. It is shallow, in average 3 m and the maximum depth is 6 m. This means that the wind is causing great disturbance throughout the water column, hereby causes unstable sediments where communities of benthic organisms are not settling. The Arresø is a highly eutrophic lake. The general levels of DOC and POC in Danish eutrophic lakes are >10 mg/L and >5 mg/L, respectively. The diversity and numbers of organisms in the Arresø will normally be high in spring, summer and autumn.

If the quality of the available test water is below the requirements, compliance will be achieved by various additions as described below:

Adjustment of water quality

Depending on weather conditions and time of the year, the water quality at the above locations may naturally fulfil the required chemical and biological water quality criteria. If the criteria are not fulfilled at the time of the test, the water quality will be adjusted by various additions. By adding organisms, it is expected that the DHI test facility will be to be able to perform land-based tests all year round.

If necessary, the number of live organisms will be increased by addition of harvested indigenous organisms and/or cultured species. Cultivation of planktonic organisms (e.g. Tetraselmis sp., Artemia cysts, Acartia sp., Daphnia sp., Skeletonema sp., Rhodomonas sp, heterotrophic bacteria) will be performed at the test facility at Hundested Harbour.

Concentrations of DOC may be increased by adding e.g., humic acids, lignin or agar-agar. Prior to the final decision on selection of source of DOC addition, pros and cons will be considered. Particulate organic carbon and TSS will be adjusted by addition of freshwater sediments or marine sediments.

The first tests will be initiated in spring 2010.

Overview of basic testing approaches and methods in brief

Organisms >50 µm: Filtration; staining; binocular microscopy; counting and movement determinations.

Organisms 10-50 µm: Filtration; microscopy; counting and movement determinations. In addition phytoplankton diversity will be determined by pigment analysis. Viability will be determination combining primary production (C^{14}) measurements and MPN analysis.

Heterotrophic bacteria and pathogens: Plate counting (CFU/ml); staining and microscopy (bacteria/ml).

Whole Effluent Toxicity (WET) test: Acute and chronic toxicity test (marine and freshwater) on algae, crustaceans and fish according to OECD test guidelines.

Unique features of the facility

- The site has direct access to high saline seawater, brackish water - and natural freshwater with natural phytoplankton and zooplankton communities in the requested amounts.

- The site is located in close proximity to DHI certified and GLP accredited laboratories (less than 1 hour drive)
- All necessary laboratory facilities, equipment and human resources (biologists, chemists, engineers and skilled laboratory technicians) in order to conduct all required tests on site and in certified laboratories (GLP and ISO 17025). This includes biological, microbiological and ecotoxicological analyses.

DHI Singapore Land Based Test Facility

Facility location: Singapore, West Coast

Ambient water parameters at site

Mix of annual variation and average data

Parameter	Sea water (Singapore Straits)	Fresh Water (Pandan Reservoir)
Temperature [°C]	28.3–31.2	28 - 31
Salinity [PSU]	28.7–32.2	< 0.3
TSS [mg/l]	1.6–54	30 (average)
POC [mg/l]	-	-
DOC [mg/l]	-	-
Organisms > 50 µm (per m^3)	$10^5 – 10^6$	-
Organisms 10 -50 µm (per ml)	$10^2 – 10^3$	10^4
Heterotrophic bacteria (per ml)	$>>10^4$	$10^5 – 10^6$

-: Parameters not measured so far. To be identified soonest possible.

The test site will be in operation from the end of 2010.

Basic testing approaches and methods:

As in Denmark (see above).

Unique features of the facility

- As a result of the warm tropical climate and high nutrient availability, the waters around Singapore are highly productive. The high biodiversity coupled with year round high abundance of plankton provides an ideal and challenging environment for testing of ballast water management systems
- The climate enables year-round operation at very constant conditions
- The site has direct access to high saline seawater, brackish water - and freshwater at a neighboring drinking water reservoir
- DHI Singapore is certified according to ISO 9001. Laboratory services follows principles of GLP

India

(Information provided by correspondence)

The National Institute of Oceanography, Goa is in consultation with Directorate General of Shipping, Mumbai regarding setting up of a state of the art Ballast Water Treatment Technology Verification and Certification Facility. This initiative finds mention on the Eleventh plan proposal of Government of India as well. The proposal from the National Institute of Oceanography looks at establishing the facility in its campus at Dona Paula Goa located on the west coast of India. The proposed land based testing facility will incorporate the G8 and G9 guidelines as on date and will have the flexibility to take up the challenges in Treatment Technology Verification.

Japan: Marine Research and Development Technology Center (MRDTC)

Authors: Yasuwo Fukuyo*[1] and Katsumi Yoshida*[2]
*[1]: Asian Natural Environmental Science Center, The University of Tokyo
*[2]: The Japan Association for Marine Safety

The Japanese Government does not establish a test facility for manufacturers, and instead it invites manufacturers to prepare their own facility through assisting them by providing information for setting necessary technologies compatible to some other known facilities constructed in other countries.

Some manufacture used the facility of The Marine Research and Development Center. The Center does not provide technical service for testing BWMS, but provides the facility and an area for testing. Manufacturers must prepare all technicians and machines for testing, and make all QA/QC controls.

Facility location: Seto-cho 2269-53, Imari-city, Saga-prefecture, 848-0043 Japan, N33 10 55, E 129 45 50 (Fig. 2).

Fig. 2. Location of the MRDTS facility (left) and inside view of a test tank (right).

Ambient water parameters at the site

- Water Temperature: 8-25 °C
- Salinity: 31-34
- TSS: 5-11mg/L
- POC: <0.1 - 1.7mg/L
- DOC: 1.0 - 1.5mg/L
- Organism concentrations: >50 (L size): 5.8×10^3 - 5.3×10^5 /m3

The site is in operation since October 2007.

Overview of basic testing approaches and methods

More than 400 cubic meters of water are filled into one of the four sections in a barge at first. At time of land-based test organisms are spiked into the challenge water. The challenge water is pumped through the ballast water management system, and then pumped back to the barge by using other than the challenge water preparation tanks. The control water was also prepared in the barge.

Tests were undertaken for the Special Pipe with Ozone treatment system.

Unique features of the facility

- Using barge as a mimic ballast water tank

Korea, KOMERI

Facility location

KOMERI is dealing with three test sites as shown in the figures below (Fig. 3).

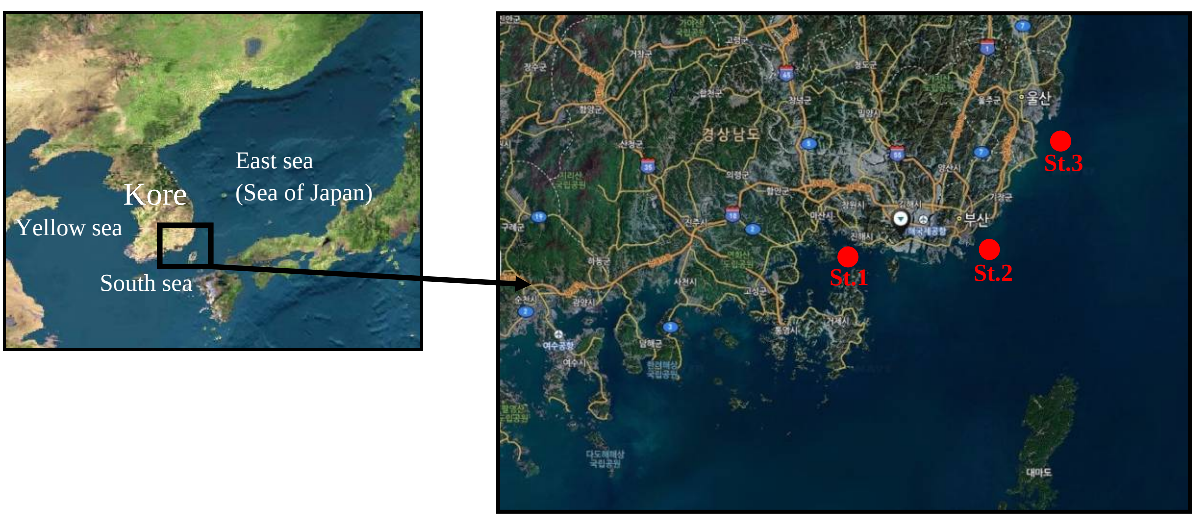

Fig. 3. Location of the KOMERI test sites.

1. Information of Test Facility

	Facility name	Developer	Latitude / Longitude	When did it start
St.1	BOG En-Ballast	21CSB* Kwang San	35°3´30.58˝/ 128°41´4.58˝	2009.09~ 2009.09~
St.2	NK-O3 BlueBallast (mobile bargeship)	NK	35°13´13.13˝/ 129°18´28.29˝	2007.04~
St.3	EcoBallast HiBallast ™ AquaStar	HHI** HHI Aqua Eng	35°30´34.06˝/ 129°30´52.99˝	2007.11~ 2007.11~ 2010.03~

*21CSB: 21th Century Shipbuilding Company.
** HHI: Hyundai Heavy Industry.

2. Water Quality Data

	Temperature(°C)	Salinity (psu)	pH	DO (mg/L)	SS (mg/L)
St.1[2]	4.7 - 26.4	31.79 - 33.51	7.76 - 8.29	5.73 – 12.04	1.1 - 22.8
St.2[3]	9.6 - 22.9	31.79 - 34.31	7.83 - 8.22	7.83 – 10.21	2.7 - 28.8
St.3[4]	8.2 - 22.8	30.31 - 34.32	7.92 - 8.31	7.02 - 9.91	3.6 - 16.3

3. Biological information

	Phytoplankton density (cells/L)				Zooplankton density (inds./m^3)			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
St.1	160,600-398,600	313,000-506,000	171,600-392,400	39,800-101,400	44,457	58,427	73,978	18,699
St.2	815-3,370	536-5,210	197-1,845	1,299-64,540	16,000	15,843	23,833	78,727
St.3	357,000-753,600	66,000-289,800	1,800-25,800	99,600-817,200	5,726	3,229	26,835	16,074

*NOTE: Phytoplankton concentration expressed in cells/L in the table. But G8 guideline expressed in cells/mL.

4. Biological diversity

	Phytoplankton				Zooplankton			
Station	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
St.1	49 spp.	44 spp.	31 spp.	34 spp.	8 Div. 34 spp.	8 Div. 40 spp.	8 Div. 46 spp.	7 Div. 24 spp.
St.2	6 Phy. 41 spp.	5 Phy. 48 spp.	5 Phy. 51 spp.	4 Phy. 31 spp.	10 Div.	23 Div.	27 Div.	14 Div.
St.3	25 Phy. 42 spp.	28 Phy. 52 spp.	22 Phy. 37 spp.	27 Phy. 44 spp.	7 Div. 31 spp.	8 Div. 51 spp.	9 Div. 44 spp.	8 Div. 36 spp.

5. Test undertaken for which treatment system

	Facility name	Component	
St.1	BOG En-Ballast	Filter + Plasma + MPUV Filter + Electrolysis + Neutralizer	
St.2	NK-O3 BlueBallast	Filter + Ozonation + Neutralizer	

	(mobile bargeship)		
St.3	EcoBallast HiBallast ™ AquaStar	Filter + MPUV Filter (optional) + Electrolysis + Neutralizer Special pipe + Electrolysis + Neutralizer	

MPUV, medium-pressure ultra violet

6. Unique features of the facility

	Facility name	Unique feature
St.1	BOG	Similar construction and is build of same materials as in ship
	En-Ballast	Round tank and bottom scrubber for water homogeneity
St.2	NK-O3 BlueBallast	Mobile barge ship
St.3	EcoBallast HiBallast ™	Can be used both seawater (>32 psu) and fresh water (reservoir, < 2 psu)
	AquaStar	

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[3], Korea Hydro & Nuclear Power. 2006. A report of environment impact assessment due to Unit 1, 2 Singori marine construction.
[4], Pusan metropolitan city. 2004. Environmental impact assessment of Myongi bridge construction.

<u>Korea, KORDI</u>

Authors: Kyoungsoon Shin and Eun-Chan Kim
Korea Ocean Research & Development Institute (KORDI), Republic of Korea

KORDI is a government-supported research institute in Korea in the field of ocean research and development. KORDI is a designated organization for land-based and shipboard testing for the type approval of ballast water management systems in Korea according to the Provisional Regulation of Type Approval of Ballast Water Management System. KORDI is also an operating laboratory that is accredited by ISO/IEC 17025 in the field of aquatic organisms.

Facility location:
The test facility (barge) is located in Masan Bay in the southern part of Korean peninsula (Fig. 4).

Fig. 4. South Sea Research Institute of KORDI (left) and test location in Masan Bay (right).

Ambient water parameters at the site are as follows:
- Temperature: 3.1-29.0^{o}C
- Salinity: 21.1-33.8PSU
- POC: 0.4-5.9mg/L (avg.=2.1mg/L)
- DOC: 0.3-32.8mg/L (avg.=9.6mg/L)
- TSS: 20-90 mg/L
- Dissolved oxygen: 4.5-16.7mg/L (avg.=9.3mg/L)
- Chlorophyll-a: 0-81.9 g/L (avg.=6.7 g/L)
- Heterotrophic bacteria: 0.24-12.7 x10^{6}cells/ml (avg.= 2.14x10^{6}cells/ml)
- Autotrophic bacteria (Cyanobacteria): 6.17 x10^{3}cells/ml
- Autotrophic microflagellates less than 20µm in size: 0.1-80 x10^{3}cells/ml (avg.= 3.2x10^{3}cells/ml)
- Heterotrophic microflagellates less than 10m in size: 0.01-7.3 x10^{3}cells/ml (avg.= 1.2x10^{3}cells/ml)
- Microzooplankton (mainly ciliate and heterotrophic dinoflagellates): 0.01-56 x10^{4}cells/L (avg.= 1.6x10^{4}cells/L)
- Phytoplankton: >1-100 x 10^{5} cells/L
- Zooplankton: 128-209,137 inds/m^{3} (avg. 19,313 inds/m^{3})

All data above were collected from the KORDI's report "Environmental Risk Assessment of the Special Management Areas in the South Sea of Korea: Masan Coast Study (2004-2006)".

Site in operation

The facility has been operated by KORDI since 2007. KORDI's type approval tests are conducted by the quality system of ISO/IEC 17025. For the viability tests of organisms, we use the photomicroscope and stereomicroscope for mobile organisms. Fluorometer and epifluorescence microscope are used for organisms, which have chloroplast, and other organisms, which can be stained by FDA. The Phyto-PAM and Turner Design 10AU fluorometer are used to determine of fluorescence.

Treatment system tests undertaken

The Techcross' Electro-Cleen (electrolysis) and Panasia's GloEn-Patrol (filter and UV) systems tested by KORDI obtained the type approval from the Korean administration.

The Netherlands, NIOZ

Author: Marcel Veldhuis (NIOZ, the Netherlands).

Facility location

NIOZ Royal Netherlands Institute for Sea Research is the National Oceanographic Institute of the Netherlands. NIOZ is part of the Netherlands Organization for Scientific Research (NWO). The institute employs around 200 people (more information on www.nioz.nl).

The mission of NIOZ is to gain and communicate scientific knowledge on seas and oceans for the understanding and sustainability of our planet. The institute also facilitates and supports marine research and education in the Netherlands and in Europe.

The NIOZ test facility is located on Texel Island (Fig. 5). Personnel from NIOZ may reach the test facility within 5 minutes and thus it is ensured that collected samples are analysed within the required time limit of 6 hours.

Fig. 5. Location of the NIOZ facility, the red circles mark the test sites.

The NIOZ test site is equipped with 3 coated concrete tanks of 300 m^3 volume each to simulate the ballast water tanks of the ship. The tanks were (steam) cleaned after each run. Water samples can be taken from bypasses of the standard piping used to fill and to empty the tanks or directly from the tank at outflow.

According to the requirements of the Guidelines G8, sampling points are fitted before the treatment system and directly after the system. Samples varying in volume from 500 ml up to 1 m^3 were taken using clean sampling containers. Sampling containers and all further handling of the samples were separated in a control and a treated set to avoid cross contamination between treated and untreated water. The basic handling, such as concentrating, filtration and chemical analysis is done at the test site. Different samples (1 to 10 L) were transported to the institute's laboratories for further special analysis.

Water parameters

Salinity 20 – 34 PSU
TSS 5 – 400 mg/l
POC 5 – 20 mg/l

Organisms	> 50 micron $10^4 – 10^6$ / m³
	< 50 and > 10 micron 100 – 10^5 / ml
	bacteria $10^4 – 10^7$ / ml

If the quality of the available test water is below the requirements, these required parameters will be met by adjustments of the water quality. However, depending on weather conditions and time of the year, the water quality may naturally fulfil the required chemical and biological water quality criteria as stated in G8.

Special samples are processed by ISO certified labs (e.g. human pathogens, ecotoxtests).

In house developed and peer reviewed methods are used to address cell counts and viability assessments.

Site in operation

The NIOZ ballast water unit is active since 2004 Contacts are established with national administrations of NL, G, Dk, UK, N, Gr and with classification societies LR, DNV, GL.

NIOZ is in close contacts with GSI, MERC, DHI and puts a strong focus on research (beyond D2) also to develop tools, methods, large picture (data base)

Treatment system tests undertaken

NIOZ was/is in contact with 35 companies/vendors. Pilot studies were undertaken for 18 and land-based certification tests for 5 companies/vendors, including

- Hamann, Germany;
- Mahle, Germany;
- Severn Trent de Nora, USA;
- Ecochlor, USA;
- Hyde.Marine, USA-Finland;
- Aquaworx, Germany;
- Alfa-Wall, Sweden;
- Coldharbour, United Kingdom; and
- EPE, Greece.

Unique features of the facility

- Its location in the Wadden Sea allows tests in challenging water conditions.

Norway, NIVA

Norwegian Institute for Water Research, Solbergstrand Marine Research Station, BWMS test facility

Authors: Tor Gunnar Jantsch, Sjur Tveite, Helge Liltved

Facility location: NIVA’s test site is located at Solbergstrand 20 km south of Oslo by the Oslo fjord (Fig. 6).

Fig. 6. The NIVA facility.

Ambient water parameters at site

Seawater is supplied from various depths down to 60 m in the Oslofjord with various salinities according to the depth, while fresh water is supplied from ground water bore holes or from a local creek. Temperature is in the range 2-15 degrees celcius depending on the season. Ambient salinity is in the range 0-34 PSU in varying amounts depending on the source water. The level of TSS, POC, DOC and organism concentration is also highly variable depending on the source water selected, but these parameters can be changed by addition of chemical compounds, harvested organisms and cultivated organisms.

Site in operation

The site has been in operation since 2004 when pilot tests were initiated during a research project to develop procedures for testing BWMS. Since 2005 test were made with focus on the IMO guidelines.

Overview of basic testing approaches and methods
Lab/pilot-scale testing to provide documentation for basic approval from IMO. Land-based testing in accordance with IMO guidelines to provide documentation for final approval and type approval. Test site physical structure, biological methodology has been verified by different national administrations and classification societies.

Treatment system tests undertaken

- Small/pilot scale tests conducted for several clients
  e.g. Alfa laval, OptiMarin, Qingdao Headway Marine Technology Co., Downstream services
- Land based testing according to IMO guidelines
  PureBallast technology, Alfa Laval, completed May 2007 (filtration, advanced oxidation)
  OceanSaver BWMS, completed December 2007 (filtration, cavitation, electrocatalytic treatment), OptiMarin BWMS, completed May 2008 (filtration, UV)
  RWO / Veolia Water CleanBallast, completed September 2008 (filtration, electrolysis)
  JFE, completed January 2009
- Shipboard testing
  PureBallast technology, Alfa Lavel, completed April 2008
  Optimarin BWMS

Unique features of the facility

- All year, all water quality facility, but varying amounts of required quality available.

South Africa

No information provided.

USA, GSI

Facility name: Great Ships Initiative RDTE Facility (Research Development Testing and Evaluation)

Author: Allegra Cangelosi, Northeast-Midwest Institute

Facility location: Duluth-Superior Harbor of Lake Superior, United States (Fig. 7).

Fig. 7. The GSI facility.

Ambient water parameters at site.

Parameter	Proposed ETV/U.S. Coast Guard†	Recommended IMO G8‡	Historic Ranges Duluth/Superior Harbor	Target Values for Amended Duluth-Superior Water
Temperature (°C)	10 - 35	–	9 – 22	9 - 22
Salinity (psu)	0 - 31	Two salinities, >10 psu difference	0 – 1	0 - 1
Total Suspended Solids (TSS) (mg/L)	> 15	> 50	2 – 21	50
Particulate Organic Carbon (POC) (mg/L)	> 1	> 5	< 1	< 1
Dissolved Organic Carbon (DOC) (mg/L)	> 3	> 5	6 – 22	6 - 22
Zooplankton (> 50 µm/m^3)	> 10,000	> 100,000	100,000 - 3,000,000	100,000 – 3,000,000
Phytoplankton (10 - 50 µm/mL)	> 100	> 1,000	25 – 1,200	> 1,000
Heterotrophic Bacteria (CFU/mL)	> 1,000	> 10,000	> 1,000 MPN/mL	5,000 – 15,000 MPN/mL

The site is in operation since 2008.

Overview of basic testing approaches and methods

- IMO Consistent
- Simultaneous Fill of Control and Treatment
- Continuous, Replicate In-Line Sampling

• Amended ambient water/assemblage
• Ability to test treatments designed for application on intake, discharge, and both intake and discharge
• Highly standardized, automated, monitored, and documented
• Heavy QA/QC

Treatment system tests undertaken

- Filtration (25 micron, 50 micron)
- Ozone/UV
- Lye/CO2
- Filtration/Electrolytic Chlorination

List any unique features of the facility

- Natural freshwater system.

USA, MERC

Facility name: Maritime Environmental Resource Center (www.maritime-enviro.org)

Authors: Dr. Mario Tamburri, Director; Mr. Ross Kanzleiter, Chief Engineer / Program Coordinator

Facility location: Testing is conducted at two locations in the Chesapeake Bay; Baltimore, MD and Norfolk, VA, USA.

Parameter	Port of Baltimore	Port of Norfolk
Temperature (^{o}C)	4 - 28	6 - 30
Salinity (psu)	5 - 15	20 - 25
Total Suspended Solids (mg/l)	1 - 60	1 - 60
Particulate Organic Carbon (mg/l)	0.5 - 6.0	1.0 - 8.0
Dissolved Organic Carbon (mg/l)	2 - 10	2 - 10
Zooplankton (> 50 mm) / m^3	10,000 - 300,000	10,000 - 300,000
Phytoplankton (10 - 50 mm) / ml	500 - 15,000	500 - 15,000
Heterotrophic Bacteria cfu / ml	10,000 - 10,000,000	10,000 - 10,000,000

Site in operation since 2008.

Overview of basic testing approaches and methods
G8/G9 and US ETV

Treatment system tests undertaken
Completed prior to MERC (prior to 2008):- Nutech O3 (ozone) – shipboard- NEI Treatment Systems (deoxygenation) – land-based and shipboard- SeaKleen (menadione) – laboratory Completed under MERC:- Maritime Solutions Inc. (filter+UV) – land-based- Siemens (filter+electrochlorination) – land-based- Severn Trent De Nora (filter+electrochlorination) – land-based- Endothall (algaecide) – laboratory Planned for 2010:- Two to three ballast filters – land-based- Maritime Solutions Inc. (filter+UV) – land-based- Siemens (filter+electrochlorination) – land-based- Techcross (electrochlorination) – land-based- Severn Trent De Nora (filter+electrochlorination) – shipboard- NEI Treatment Systems (deoxygenation) – shipboard

Unique features of the facility

- Mobile test platform for testing in two different locations (salinities).

<u>USA, NRL</u>

Naval Research Laboratory, Key West

Authors: Lisa A. Drake, Mia K. Steinberg, and Edward J. Lemieux

Facility location: The ANS program at Naval Research Laboratory is located in Key West, Florida, USA (NRLKW; Fig 8).

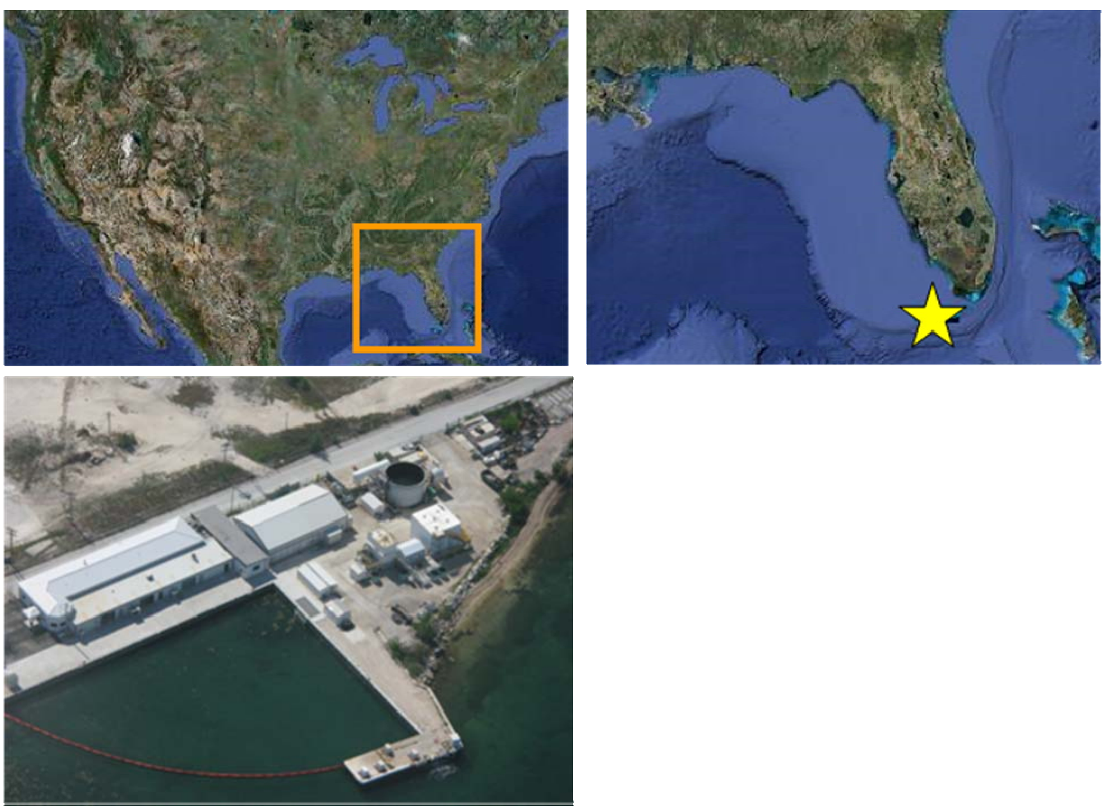

Fig. 8. Naval Research Laboratory in Key West, Florida (NRLKW). Top images show NRKLW's location in the United States (images courtesy of Google Earth); the bottom photograph shows the ANS laboratory buildings.

Ambient water parameters at site

The laboratory is surrounded by warm, salty, oligotrophic water (Table 1).

Table 1. Physical and biological characteristics of the water surrounding NRLKW.

Parameter	Range at NRL
Temperature	20 – 32°C
Salinity	35 – 41 psu
DOC	2 – 4 mg l^{-1}
POC	2 – 4 mg l^{-1}
Mineral Matter	1 – 5 mg l^{-1}
Organisms ≥ 50 µm (nominally zooplankton)	50 – 180 l^{-1}
Organisms ≥ 10µm and > 50 µm (nominally protists)	~10 - 200 ml^{-1}
Heterotrophic bacteria (colony forming units)	10^5 – 10^7 ml^{-1}

Site in operation

The ANS facility has been in operation since 2004. The multi-disciplinary ANS team is comprised of engineers (5), a physical scientist, a computer scientist, facilities engineers (3), biologists (3; with a post-doctoral researcher to join the group in March), and a statistician. The biologists and two engineers dedicate all of their time to the project; the other team members also have additional non-ANS responsibilities.

Overview of basic testing approaches and methods in brief

The fluid storage components of the ANS facility include two full-scale ballast water tanks (151 m^3 and 394 m^3 volumes) and a Pre/Post-Treatment Tank (382 m^3). Fluid is handled by seawater supply pumps (four 30 hp pumps, 136 m^3 hr^{-1} each) and ballast pumps (two 60 hp pumps, 363 m^3 hr^{-1} each) to allow a test water pump rate of 300 m^3 h^{-1}.

<u>Organisms ≥ 50 µm (nominally zooplankton)</u>: Filtration; staining with fluorescent, vital stains and examining with microscopy to quantify stained and moving organisms.

<u>Organisms ≥ 10 µm and > 50 µm (nominally protists)</u>: Filtration; staining with fluorescent, vital stains and examining with microscopy to quantify stained and moving organisms.

<u>Heterotrophic bacteria:</u> Plate counting on marine media (CFU ml^{-1}).

Treatment system tests undertaken

Four valid tests of the Severn Trent de Nora BalPure™ electrolytic chlorination treatment system were conducted at NRLKW from October 2006 – February 2007 as a beta test of the US

Environmental Protection Agency’s Environmental Technology Verification protocol (Lemieux et al., in review).

Unique features of the facility

- The fluid handling system is monitored by > 200 sensors and actuators and controlled by a Honeywell Experion® programmable logic controller for system-wide control and data acquisition.
- The site has a flow-through sampling for concentrating large samples.
- The following technical testing issues have been addressed at NRLKW: design, construction and operation of discharge sample ports; valve effects on organism mortality; control and automation of ballast water management system testing; mode of injection for standard test organisms and ambient organisms; augmentation of ambient POC and DOC; concentration of ambient organisms; population dynamics within ballast tanks; post-collection sample degradation time; comparison and development of methods for protist viability; determination of zooplankton viability; development of a discharge sampling system; validation of discharge sampling system (inorganic microbeads); statistics of sampling.

References

Lemieux EJ, Grant J, Wier T, Drake L, Robbins S, Burns K (in review) Generic Protocol for the Verification of Ballast Water Treatment Technologies, Version 3.2. Submitted to the EPA Environmental Technology Verification Program